

Opportunities at US and International Underground Facilities: the NSF viewpoint



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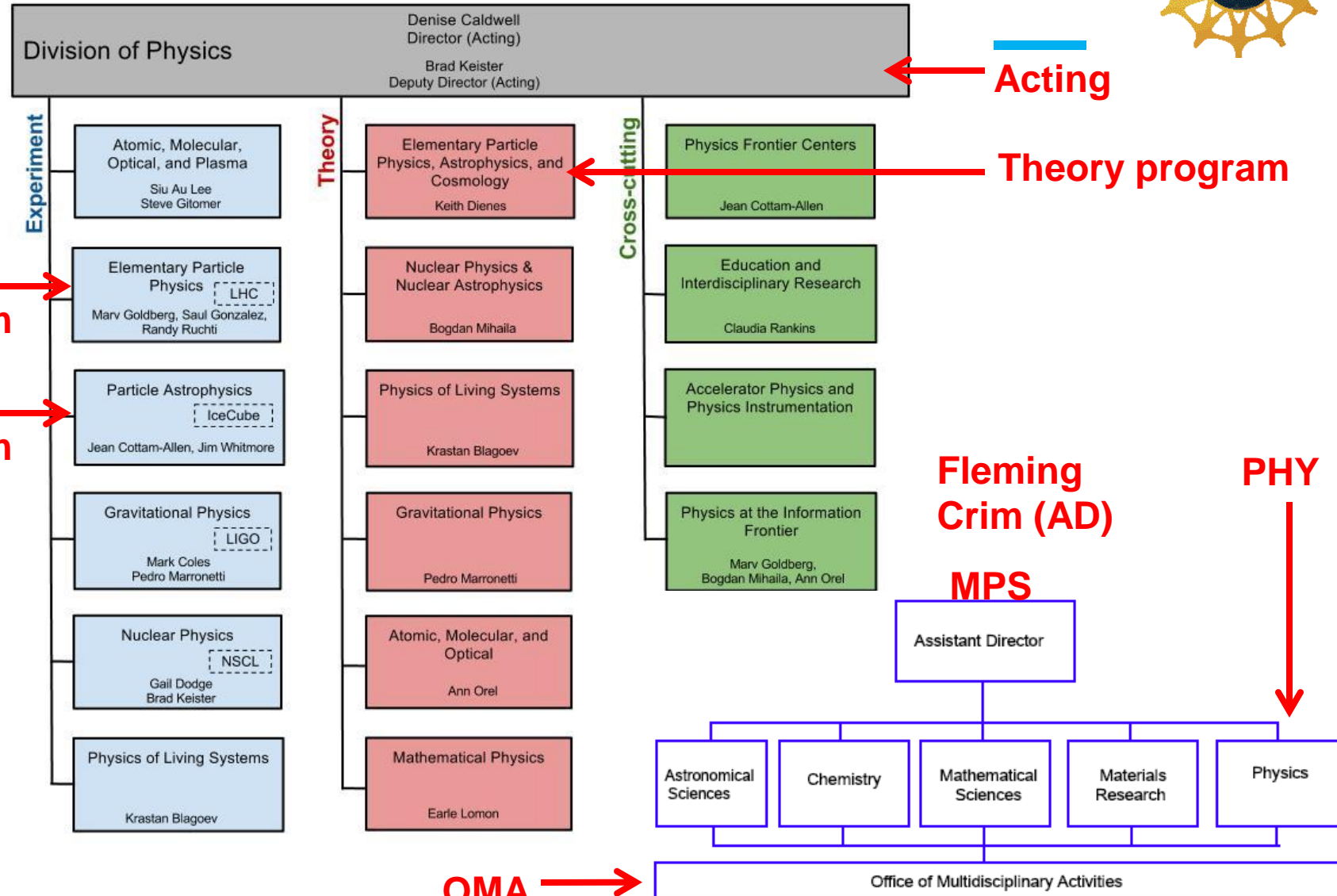
Theme: Physics of the Universe: to support Particle Astrophysics projects doing world-leading, potentially transformative science – at any location (**for experiments, in or out of the US**)

Outline:

- **NSF Personnel changes, Mission, FY2013 Funding**
- **Particle Astrophysics Program (projects and funding)**
- **Projects supported for Underground Science**
 - **Dark Matter**
 - **Neutrino Properties and Solar Neutrinos**
 - **Underground R&D**
- **Opportunities for NSF Funding**
- **New NSF Programs and Requirements**



Mathematical and Physical Sciences (MPS) Directorate



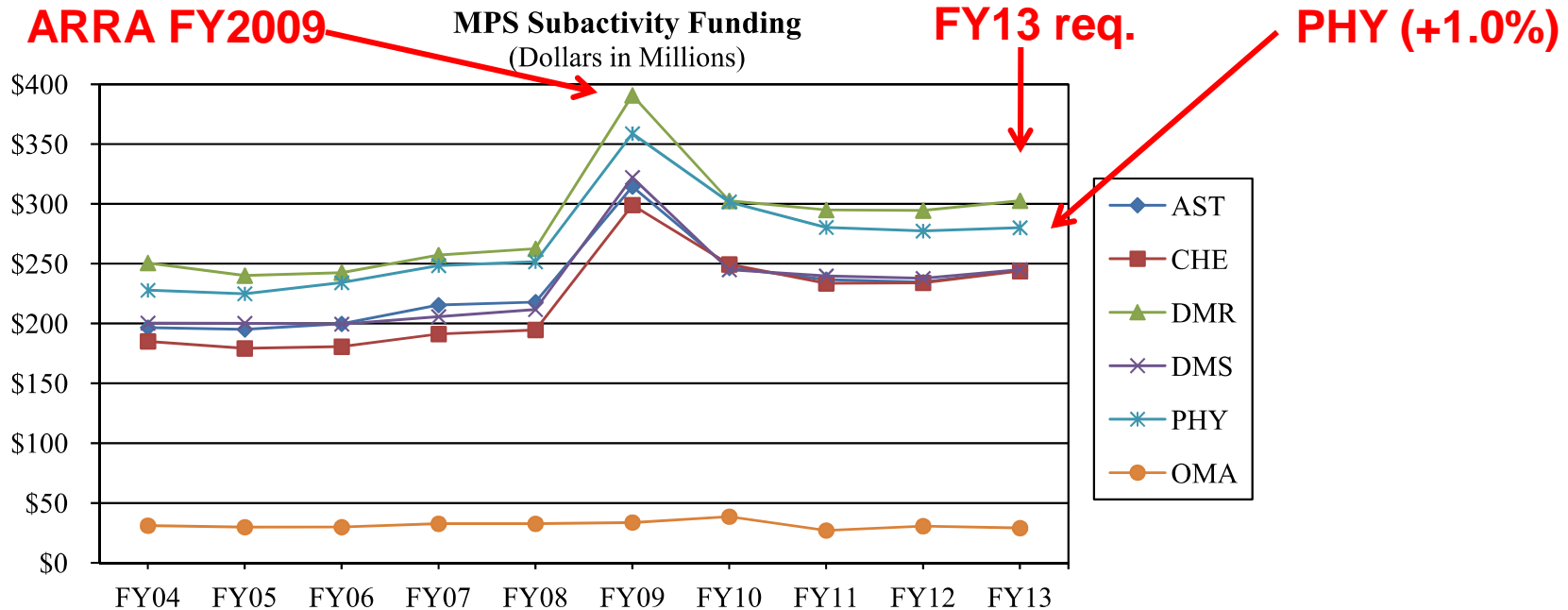


“NSF’s Mission”

- NSF’s mission is *“to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes.”*
- *We consider training postdocs and graduate students to be a high priority*
- The Particle Astrophysics (PA) and Elementary Particle Physics (EPP) Programs are highly flexible programs that can respond to the science community and the dynamics of a rapidly evolving experimental field
 - **We respond to proposals**
- The programs are coordinated with other agencies of the federal government as well as with international organizations. We work closely with the Offices of High Energy Physics and Nuclear Physics at the DOE and, for PA, we coordinate with the Astronomy Division at NSF.
- We solicit advice concerning strategic directions from advisory committees such as HEPAP, NSAC, AAAC, and the NAS.



NSF/MPS FY2013 Budget News



The FY 2012 enacted was **\$7,033.06 M** (2.5% increase over FY2011 enacted)

The FY 2013 Admin. request was **\$7,373.0 M** (4.8% increase over FY2012 enacted)

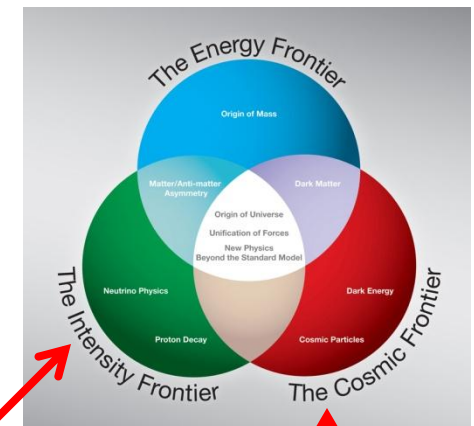
We are currently under a Continuing Resolution (CR) until **March 27, 2013**

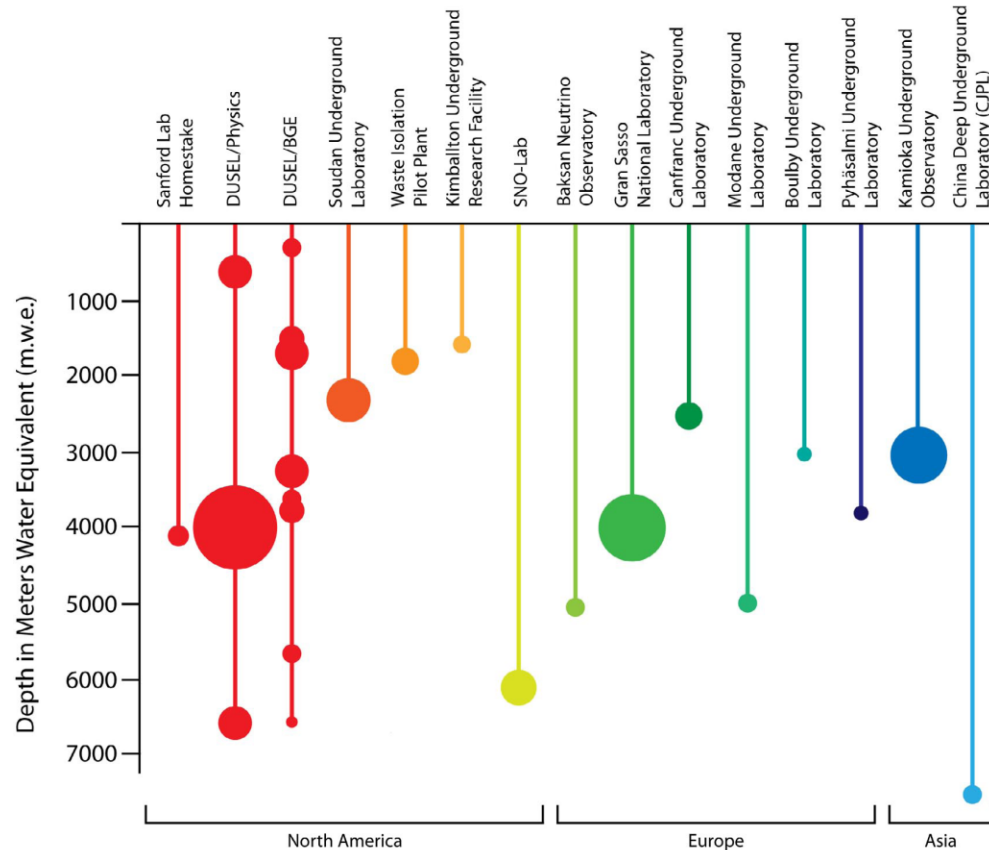
OMB says that “sequestration will require an annual reduction of **roughly 5%** for nondefense programs” NSF Director Suresh says this “would cause a reduction of nearly 1000 less research grants, impacting nearly 12,000 people supported by NSF.”



What does the Particle Astrophysics program cover?

- Particle Astrophysics encompasses studies of the present-day Universe and spans the fields of high-energy astrophysics, cosmology and elementary particle physics.
- Cosmology describes the evolution of the Universe from its beginning to the present.
- Formerly separate questions in cosmology (the universe on the largest scales) and quantum phenomena (the universe on the smallest scales) become connected through our understanding that the early universe can be explored through the techniques of particle physics.
- To do this, we fund studies of the current Universe in order to learn about an earlier Universe. They include:
 - **the search for dark matter particles**, the search for understanding dark energy, and cosmology;
 - the study of the particles comprising the High Energy Universe;
 - **the studies of neutrinos and their elusive properties.**
- The PA program currently supports 34 projects (expts/detectors), 140 PIs, 63 postdocs and 126 graduate students;
- Some projects are funded by NSF alone, some in cooperation with DOE (both OHEP and ONP).
- Most (~2/3) of the experimental projects are located off-shore





Of the 35 projects supported by PA, 11 are located in the US (two are planning to move out with their next upgrade) and

24 are located outside the US in Italy (underground), Canada (ug), UK (ug), Argentina, Mexico, Antarctica (ug), France (ug), China (ug), Japan (ug) and Chile.

Of the 13 underground labs shown, the PA program supports activities at 8 of them.

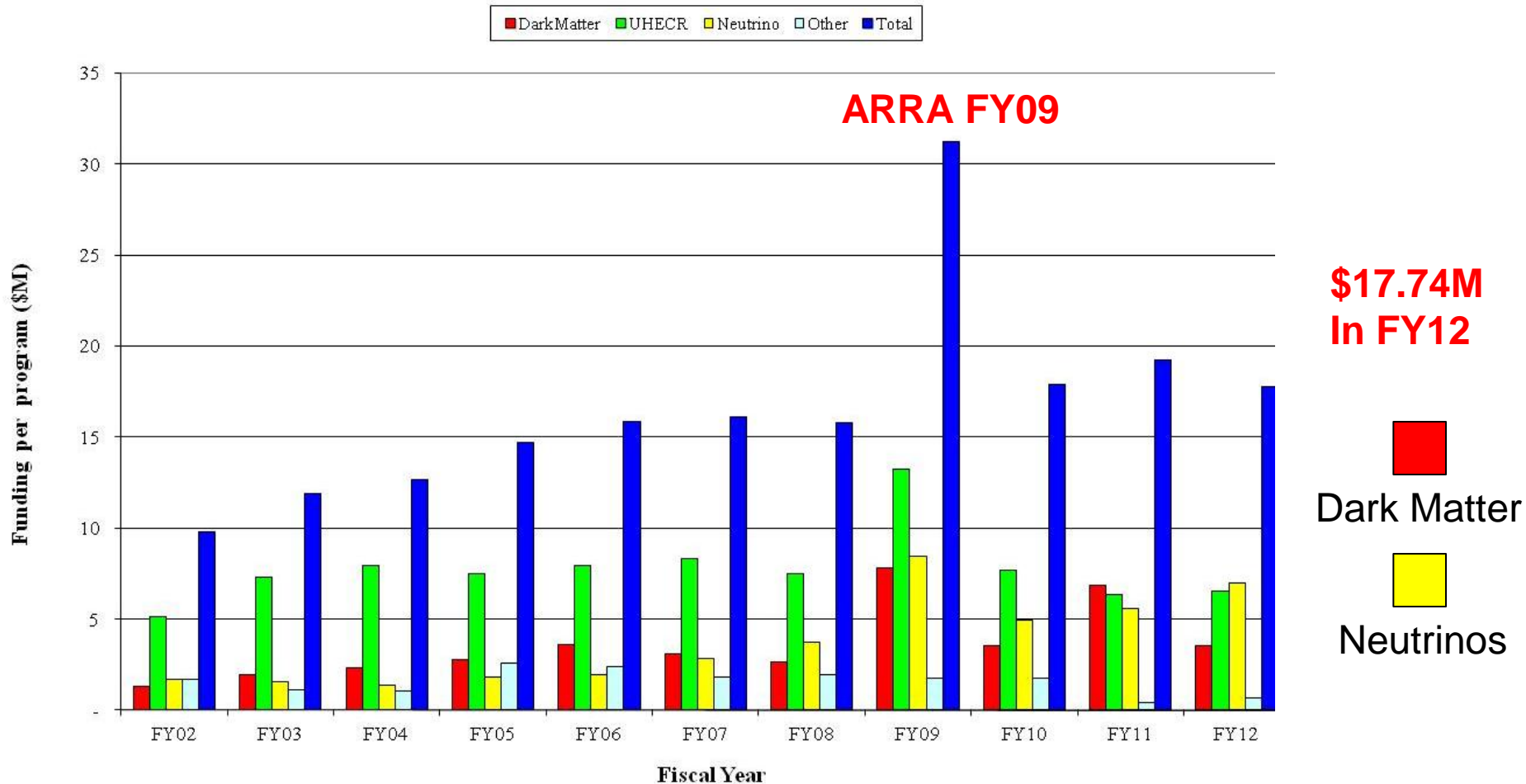
FY 2012 President's Budget under Terminations, Reductions and Savings

NSF will continue to solicit grant proposals for future particle physics research, including small-scale underground experiments that might be conducted at Homestake (should DOE decide to support the core infrastructure there) or at other existing sites in the United States and around the world.



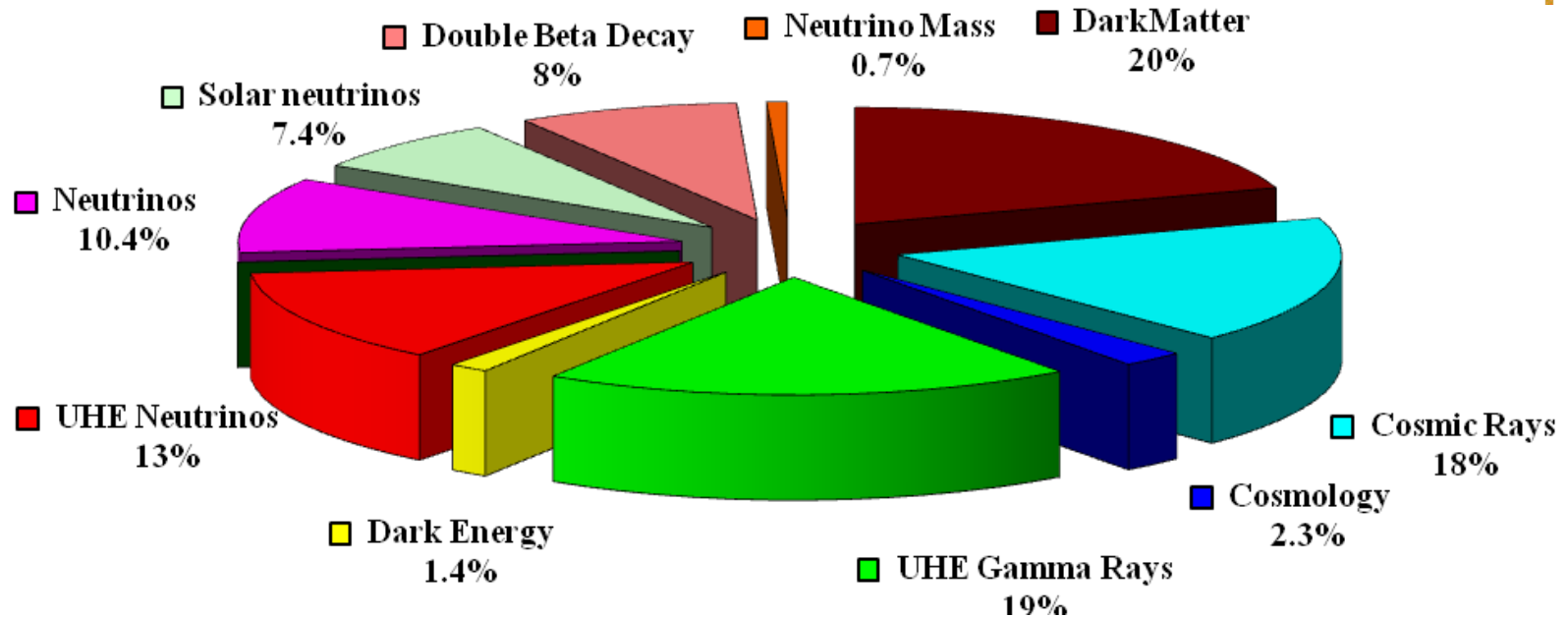
PA Funding FY02-FY12

Yearly Funding for PA Program (\$K)





PA Funding in FY12



- Search for **Dark Matter (20% of the funding)**;
- Study of the particles comprising the **UHE Universe** (ultra-high energy cosmic rays, gamma-rays and neutrinos) **(50%)**;
- Detection of solar neutrinos and the attempts to determine the absolute value of the mass of **Neutrinos** as well as some of their elusive properties **(26.4%)**;
- Search for understanding **Dark Energy, Cosmology (3.6%)**



Underground Dark Matter – 1 (20%)

WIMP searches

At Soudan:

S-CDMS – at Soudan Constr/Ops/6 groups (Ge)

CoGeNT – 1 group (Ge)

At SNOLAB:

COUPP – 2 groups

PICASSO – 1 group

MiniCLEAN – 1 group (Ar/Ne)

At LNGS:

XENON100: Constr/Ops and 4 groups (Xe)

DarkSide50: Constr. + 6 groups (DAr)

At SURF

LUX – Constr/2 groups at SURF (Xe)

Directional projects:

DRIFT – Constr/Ops and 3 groups at Boulby

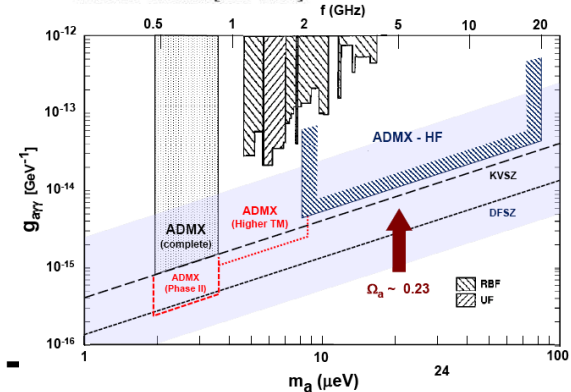
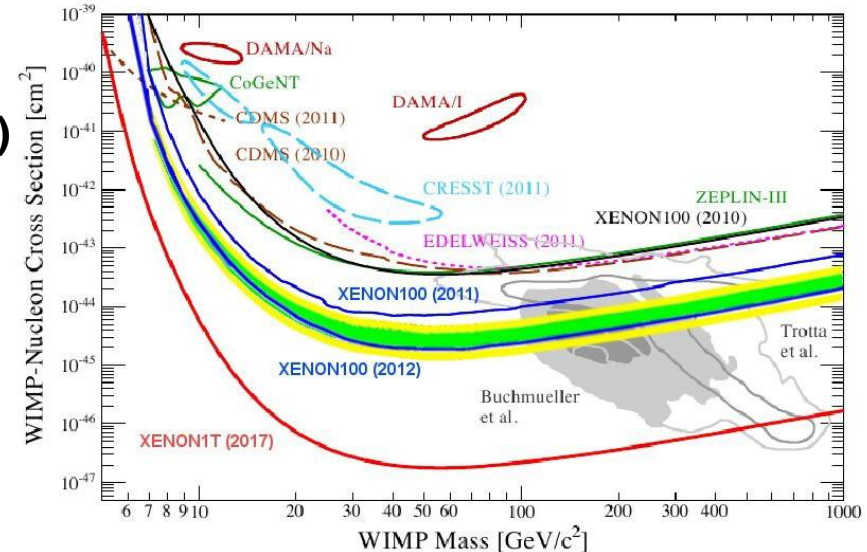
DMTPC – Constr only, at WIPP

Axion searches

ADMX-HF – Axion Dark Matter eXperiment – High Frequency -

Constr. (at Yale) (1 Group) this is the first axion search funded (2011) by PA

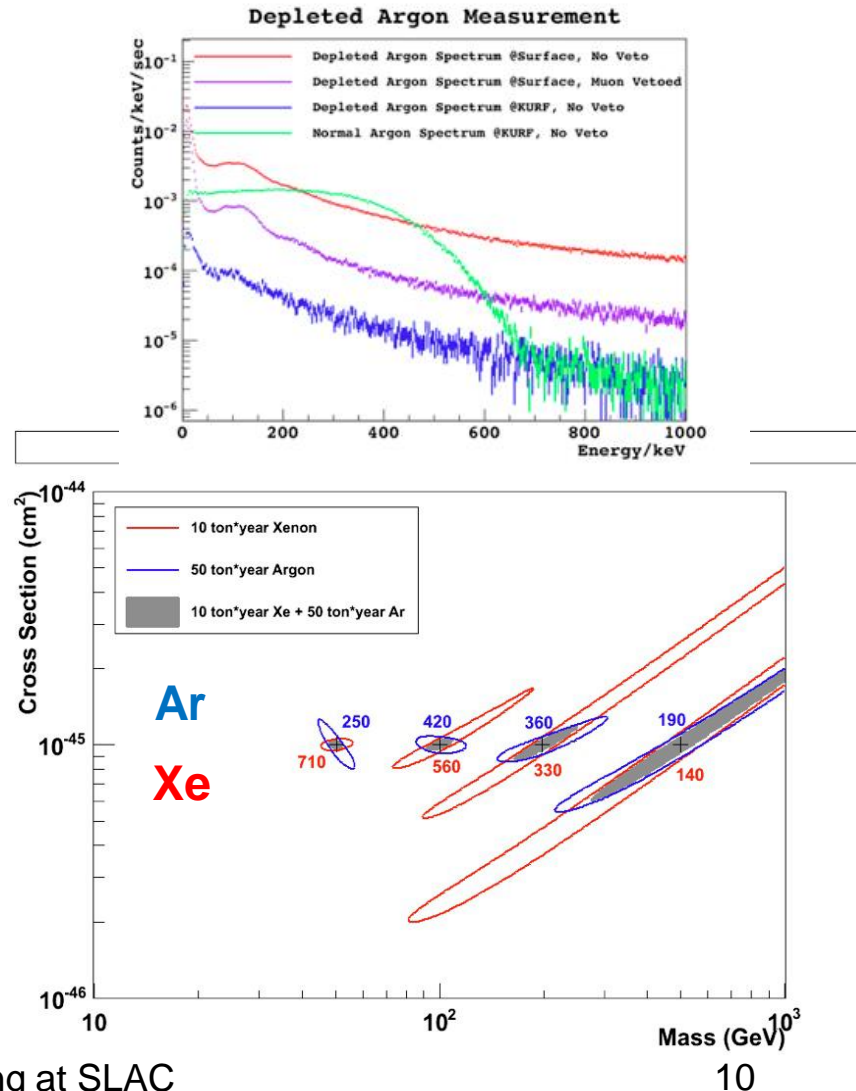
(DOE-OHEP, INFN, UK, Canada, France, Germany, Israel, Poland, Portugal, Switzerland)





Underground Dark Matter – 2 (20%)

- PA has provided funding to enable the Princeton U. group to collect argon from underground sources that is greatly reduced in the radioactive ^{39}Ar that is found in atmospheric argon, thus making it an excellent choice for low background experiments, such as Dark Matter searches.
- It is important to have at least two different technologies, e.g. Xe and Ar: in FY2010 PA funded the DarkSide-50 project to go inside the Borexino CTF (~fully funded)
- G2 funding for XENON1T (PHY will provide ~\$7.5M) -- approved at LNGS, significant non-US funding also obtained
- DARWIN (US groups involved in design studies – tech design in 2013)



Underground Neutrino Experiments (11%)

Reactor Neutrinos:

Double Chooz – Constr/Ops/4 groups support (France)

Daya Bay – 3 groups base only (China)

Neutrino mass measurements:

Mare-I & II (2 groups) cryogenic microcalorimeters ($\sim 2, 0.1-0.2$ eV/c²)

U. Genoa

(DOE-HEP&NP, INFN, France, Germany, Brazil, Japan, Russia, Spain, UK)



DC Outer veto (complete)

Project 8 (radio frequency techniques to observe the cyclotron radiation from beta-decay electrons trapped in a magnetic bottle) with DOE-ONP, OHEP

IceCube ν oscillations at Very High Energy (muon-to-tau oscillations)

Neutrinoless Double Beta Decay searches (8%)

CUORE (LNGS): 4 groups; NSF is funding the construction, testing and installation of the electronics (Milano design)

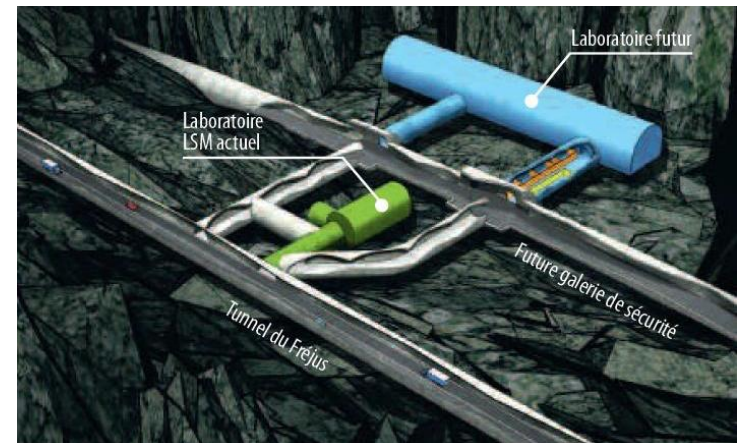
Majorana MJD (Homestake); providing funds to import ~60 kg of germanium enriched to ~86% in ^{76}Ge in the form of GeO_2 , reduce it, purify it, and zone refine it to the level of $\sim 10^{13}$ electrically active impurities/ cm^3 , normally accepted by the germanium detector manufacturers.

EXO-200 (WIPP) base support for 2 groups

SuperNEMO (Modane Underground Laboratory in the Fréjus Tunnel under the French-Italian Alps) support for 1 group **combines tracking, calorimetry and ToF** (^{82}Se)
0.04-0.14 eV ($>1.5 \times 10^{26}$ yr)



Safe, in cave at Oak Ridge





Solar Neutrinos (7.4%)

Borexino (at LNGS, 3 groups)

Geoneutrinos: studies of the energy production (internal heat) of Earth

^8B and ^7Be real time spectra of solar neutrino fluxes

ν -oscillations

pep neutrinos

(co-fund PA, and Italian groups)

Mini-LENS (at **Kimballton**) Neutrinos from the Sun are ideal for studying ν -flavor phenomena and astrophysics. A precision measurement of the neutrino-derived luminosity of the Sun is possible only by the detection of low-energy (<2 MeV) solar neutrinos that contain $> 99.9\%$ of the flux. The indium-based Low Energy Solar Neutrino Spectrometer, LENS will provide a nearly background-free complete spectral image of solar neutrinos using CC-based neutrino detection

at **SNOLAB**

HALO (Helium and Lead Observatory) for SN neutrinos

SNO+ (a new kilo-tonne scale liquid scintillator neutrino detector)



Underground Physics R&D

- Ba tagging (liquid and gas) for EXO
- Depleted underground Argon – Princeton, at Colorado and Fermilab
- NaI in Borexino CTF (DM search)
- Ge Purification – MJD
- NSF is also funding R&D into P-type Point Contact (PPC) Ge detectors
- DM-ICE at IceCube (NaI)
- AARM (Assay and Acquisition of Radiopure Materials)
- **DCL** (August 2012) \$13.6M for underground activities (FY12-13, combined)





Funding Opportunities in PHY

- Submission dates for Proposals to PHY:
- **July 24** – CAREER FY14 proposal deadline (MPS)
- **October 30** – Probable target date for FY14 EPP and PA Base program proposals



PA Construction and R&D Funding levels (\$M)

FY	Undrgnd R&D	PHY	MPS OMA	MRI PHY	MRI OPP	EPSCoR	Sum		PA program
07	3.11						3.11		2.20
08	4.96	2.00	1.90	0.61			9.47		1.89
09	4.00	2.00		2.22	2.80		11.02		2.37
10	4.50	2.18		1.63			8.31		1.49
11	4.59	4.05		0.20	0.86	0.26	9.96		0.47
12	11.0	11.9		3.66		0.16	26.8		??
Totals	32.16	22.1	1.90	8.32	3.66	0.42	68.7		

DCL funding

Construction Funds only

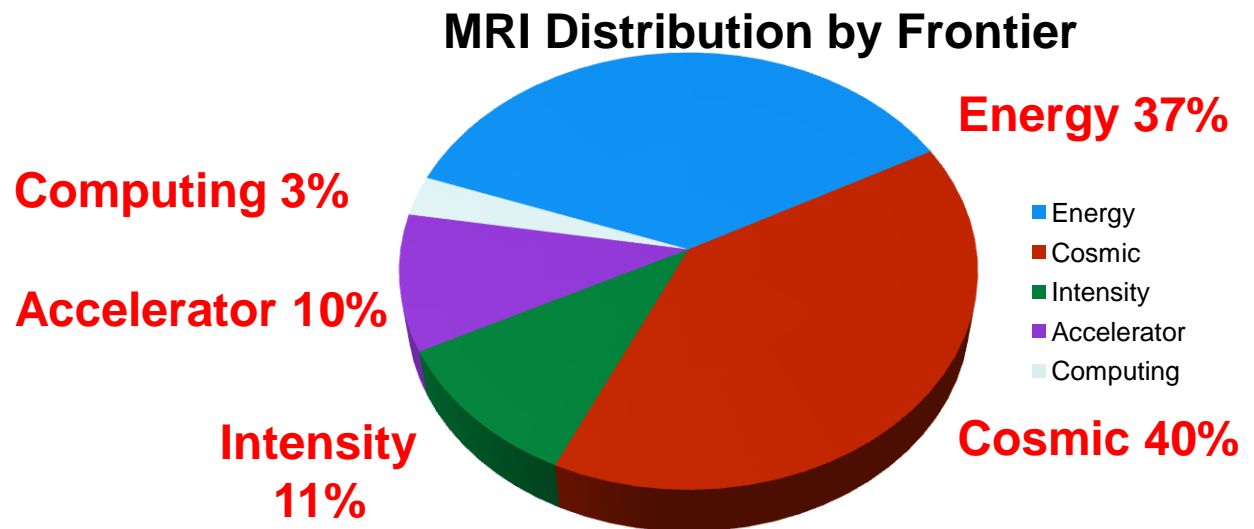
- MRI is Major Research Instrumentation

NSF MRI (FY06-12)



- Novel Telescope for VHE Gamma-Ray Astrophysics
- HAWC-256 Wide-Field Gamma Ray Detector
- VERITAS improved instrumentation
- Radar Observatory for Cosmic Ray Air Showers
- Development of the ARIANNA Telescope Instrument
- Research Infrastructure for Neutrino and Astroparticle Physics
- Atom Trap Trace Analysis System to Measure Ultra-Low Kr Contamination in Xe
- Ultra-clean, Underground Electroforming and Parts Fabrication Instrumentation Facility

\$24.1M
EPP+PA





Funding opportunities in NSF

- **MRI** – **Jan 2014** deadline (internal University competition is earlier)
- **INSPIRE** – **March 29, 2013**: Track 1: LOI deadline
- **GOALI**
- **CDS&E, BIGDATA, DIBBS**



Integrated NSF Support Promoting Interdisciplinary Research and Education (INSPIRE)

- Program: INSPIRE was established to address some of the most complicated and pressing scientific problems that lie at the intersection of traditional disciplines. It is not intended for proposals that are more appropriate for existing award mechanisms.
http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=504852
- Solicitation: 13-518: <http://www.nsf.gov/pubs/2013/nsf13518/nsf13518.pdf>
- Several types of proposals and awards: **Letters of Intent are mandatory**
 - **Track 1: LOI deadline of 29 Mar 2013; support \leq 1M; internal review**
 - Director's INSPIRE awards – within Track 1: support \leq 1.5M
 - **Track 2: LOI deadline of 20 Feb 2013; support \leq 3M; external review**
- **Full proposal submission by invitation only from at least two NSF program directors from intellectually distinct NSF divisions or programs.**
 - Track 1 proposals: Invitations 29 Apr 2013; Deadline 29 May 2013
 - Track 2 proposals: Invitations 29 Mar 2013; Deadline 13 May 2013
- Limitations:
 - No organizational limit
 - No cost sharing requirement
 - Only one LOI submission per PI. A PI on one LOI may be a collaborator on other LOIs.
- **“Potentially Transformative Research” in more than one (NSF) Division**

Grant Opportunities for Academic Liaison with Industry (GOALI)



- This solicitation targets high-risk/high-gain research with a focus on fundamental research, new approaches to solving generic problems, development of innovative collaborative industry-university educational programs, and direct transfer of new knowledge between academe and industry. GOALI seeks to fund transformative research that lies beyond that which industry would normally fund.
- NSF funds cannot go to an industry partner, they can only be used by the academic institution. The industry partner is expected to participate to facilitate the commercialization.
- Program Announcement
 - http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=504699
- Solicitation 12-513
 - <http://www.nsf.gov/pubs/2012/nsf12513/nsf12513.pdf>



Data Infrastructure Opportunities

- Computational and Data-Enabled Science and Engineering (**CDS&E**: PD 12-8084)
- MPS, ENG, and OCI have recently established a new cross-directorate program. For Physics, CDS&E proposals come through the existing PIF-CP program.
- ***“The goal of the CDS&E program is to identify and capitalize on opportunities for major scientific and engineering breakthroughs through new computational and data analysis approaches. The intellectual drivers may be in an individual discipline or they may cut across more than one discipline in various Directorates.***
- Core Techniques and Technologies for Advancing Big Data Science & Engineering (**BIGDATA**): Solicitation NSF 12-499 ***“to advance the core scientific and technological means of managing, analyzing, visualizing, and extracting useful information from large, diverse, distributed and heterogeneous data sets***
- Data Infrastructure Building Blocks (**DIBBS**): Solicitation NSF 12-557
- ***“DIBBs, a program to develop data infrastructure usable by multiple scientific disciplines, recognizing these disciplines may vary in their current state of development.***



New requirements for NSF proposals/awards

- Just a “heads-up”:
- (Now require a Data Management section and PD mentoring)
- For any **proposal submitted** after **March 18, 2013** there will be “automated compliance checking of required sections of proposals.” (See Grant Proposal Guide):
- Sections will have boxes requiring some text
- **Reporting has also changed (March 18, 2013)**
- New service in **Research.gov** for PIs, co-PIs, SPOs
- Replaces annual, final, and interim project reports in FastLane
- Structured data collection



Backup slides



NSF Funding (total)

- Current status:
- The FY 2011 enacted was **\$6,859.9** million
- The FY 2012 Administration request was **\$7,767.0** million
- The FY 2012 enacted was **\$7,033.06** million (**2.5%** increase above FY2011 enacted)
- The FY 2013 Administration request was **\$7,373.0** million (**4.8%** increase above FY2012 enacted)
- Currently under a Continuing Resolution (CR) until March 27, 2013



MPS FY2013 Budget Request

FY 2013 NSF request was **\$7,373M; 4.8%** above the FY2012 Appropriation

DIRECTORATE FOR MATHEMATICAL AND PHYSICAL SCIENCES (MPS)

\$1,345,180,000
+\$36,240,000 / 2.8%

MPS Funding (Dollars in Millions)

	FY 2011 Actual	FY 2012 Estimate	FY 2013 Request	Change Over FY 2012 Estimate	
				Amount	Percent
Division of Astronomical Sciences (AST)	\$236.78	\$234.55	\$244.55	\$10.00	4.3%
Division of Chemistry (CHE)	233.55	234.06	243.85	9.79	4.2%
Division of Materials Research (DMR)	294.91	294.55	302.63	8.08	2.7%
Division of Mathematical Sciences (DMS)	239.79	237.77	245.00	7.23	3.0%
Division of Physics (PHY)	280.34	277.37	280.08	2.71	1.0%
Office of Multidisciplinary Activities (OMA)	27.06	30.64	29.07	-1.57	-5.1%
Total, MPS	\$1,312.42	\$1,308.94	\$1,345.18	\$36.24	2.8%

Totals may not add due to rounding.

← PHY
1.0%

National Academy of Sciences Report



National Academy of Sciences: An Assessment of the Deep Underground Science and Engineering Laboratory (Board on Physics and Astronomy, July 2011)

Laboratories located deep under the surface provide a unique environment where scientists can study the behavior of the smallest subatomic components of matter, shielded from the cosmic rays and other environmental “noise” that permeate the environment on the surface. The research pursued in these laboratories has the potential to make profound contributions to our understanding of nuclear and particle physics. This study ... identifies the most important questions and experiments that could be addressed by the proposed program of research.

From the list of proposed experiments, the study identified three as the top priorities:

- **The direct detection dark matter experiment;**
- **The long baseline neutrino oscillation experiment; and**
- **The neutrinoless double beta decay experiment**

Because these three experiments address fundamental questions at the forefront of physics research, all could produce a breakthrough discovery upon which the future of particle, nuclear, and astrophysics will be built. For this reason, and to foster future U.S. leadership in the expanding field of underground science, **the committee concluded that United States should proceed with plans to conduct the above three experiments, even if they must take place in a facility other than DUSEL.**